Checkin 13

Explain why an LL(1) parser has trouble with immediate left recursion but an SLR does not

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Explain why an LL(1) parser has trouble with immediate left recursion but an SLR does not

University of Kansas | Drew Davidson

EECS 665 COMPILER CONSTRUCTION

Scope

Last Time

Lecture Review - LR Parsing

LR Parser Construction

- LR Parsers
- Building SLR Parser tables

<u>You Should Know</u>

- How to build an SLR Parser
  - Item Closure Set
  - Item Set GoTo
- Creating an SLR Parser Table
  - Action Table
  - Goto Table
  - Accept / Reject

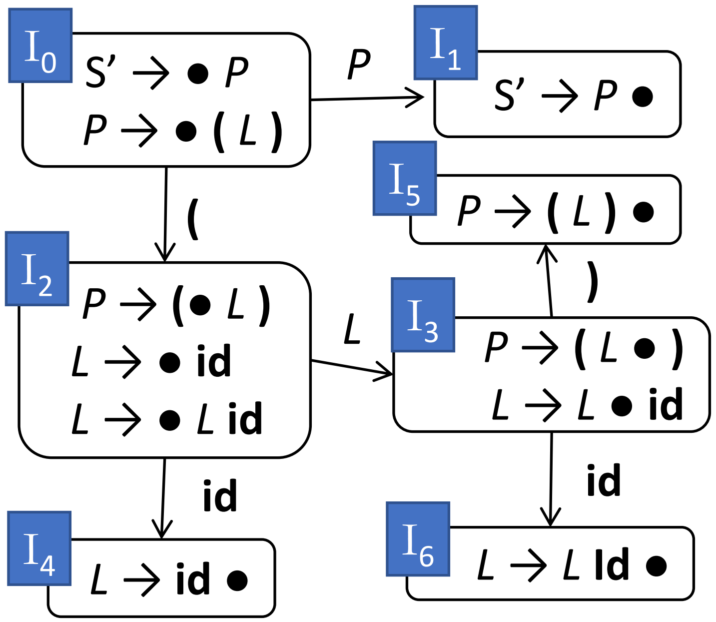
Parsing

Building FSM

LR Parser Construction

Grammar G

1. $S' ::= P$
2. $P ::= (L)$
3. $L ::= \textbf{id}$
4. $L ::= L\ \textbf{id}$

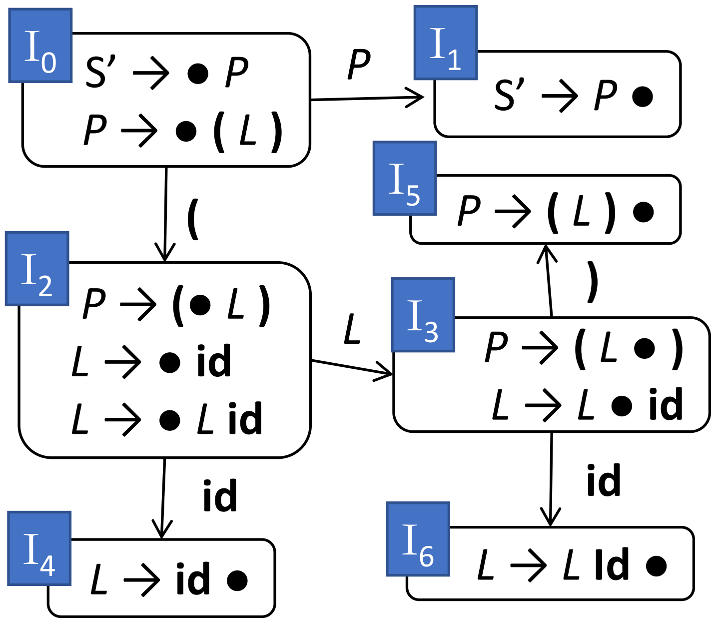


Convert FSM to Table

LR Parser Construction

Grammar G

1. $S' ::= P$
2. $P ::= (L)$
3. $L ::=$ **id**
4. $L ::= L$ **id**



	Action Table				GoTo Table	
	(	**)**	**id**	**eof**	***P***	***L***
I_0	S I_2				I_1	
I_1				☺		
I_2			S I_4			I_3
I_3		S I_5	S I_6			
I_4		R❸	R❸			
I_5				R❷		
I_6		R❹	R❹			

Outline

Today's Lecture - Scope

Finish up Parsers

- Running the SLR Parser
- LL(1) and SLR ~~Language~~ limits

grammar

Semantics

- Program meaning

Scope

- Name analysis

Parsing

Running the SLR Parser

LR Parser Construction

Grammar G

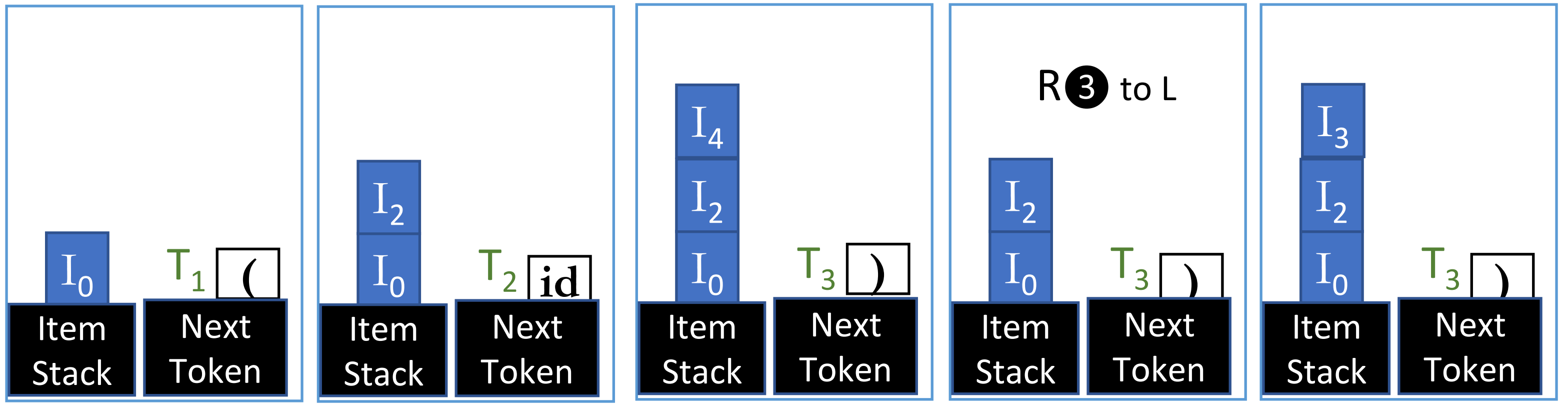
1. S' ::= P
2. P ::= (L)
3. L ::= **id**
4. L ::= L **id**

Input String

(id) eof

Action Table / GoTo Table

	(	)	id	eof	*P*	*L*
I_0	S I_2				I_1	
I_1				☺		
I_2			S I_4			I_3
I_3		S I_5	S I_6			
I_4		R 3	R 3			
I_5				R 2		
I_6		R 4	R 4			



Running the SLR Parser

LR Parser Construction

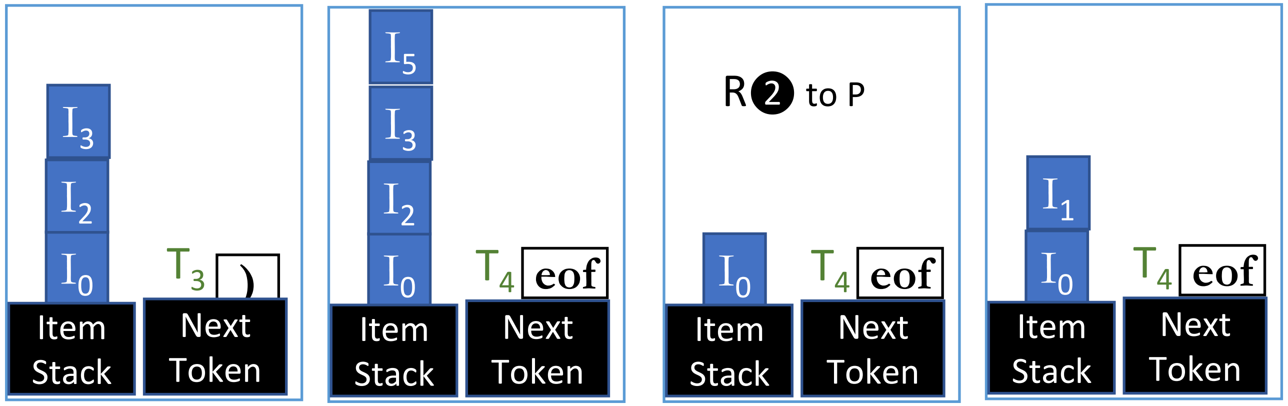
Grammar G

1. $S' ::= P$
2. $P ::= (L)$
3. $L ::=$ **id**
4. $L ::= L$ **id**

Input String

(id) eof

	Action Table				GoTo Table	
	(	)	id	eof	*P*	*L*
I_0	S I_2				I_1	
I_1				☺		
I_2			S I_4			I_3
I_3		S I_5	S I_6			
I_4		R 3	R 3			
I_5				R 2		
I_6		R 4	R 4			



Outline

Today's Lecture - Scope

Finish up Parsers

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- LL(1) and SLR Language limits

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- Program meaning

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- Name analysis

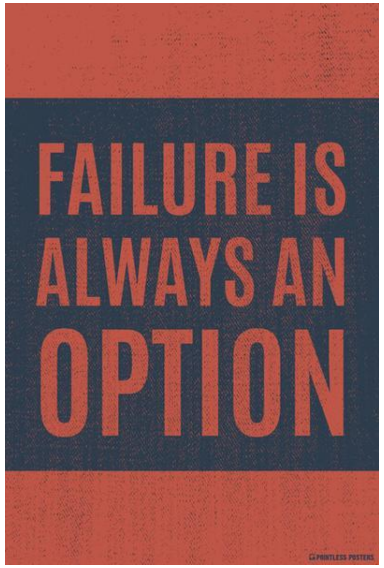
Parsing

When Does the Parser Fail?

LL(1) and SLR Language Limits

For both the LL and LR parsers, two types of failure:

- *Running the parser fails:* The input isn't in the language
- *Building the parser fails:* The language is too expressive



When Running The Parser Fails

LL(1) and SLR Language Limits

The input string is rejected

- Happens whenever either parser table indexes an empty cell
- Happens whenever either parser gets to the end of input without the accept condition

This is the parser working as intended

- Just means the user is at fault with bad input

When Does the Parser Fail?

LL(1) and SLR Language Limits

How building the parser fails

- Happens whenever two entries are in a cell
- For LR parsers, multiple types of collision:
  - Shift/Reduce: a reduce and a shift action in the same cell
  - Reduce/Reduce: reduce by two different productions

This is a problem!

- Means the language isn’t captured by the formalize (e.g. it’s not LL(1), not SLR, whatever)

Bottom-Up SDT

LL(1) and SLR Language Limits

Fairly intuitive

- Add a translation type to each item
- Like LL(1) parser, items are popped right-to left

Terminals translations

- Read lexeme value during a shift

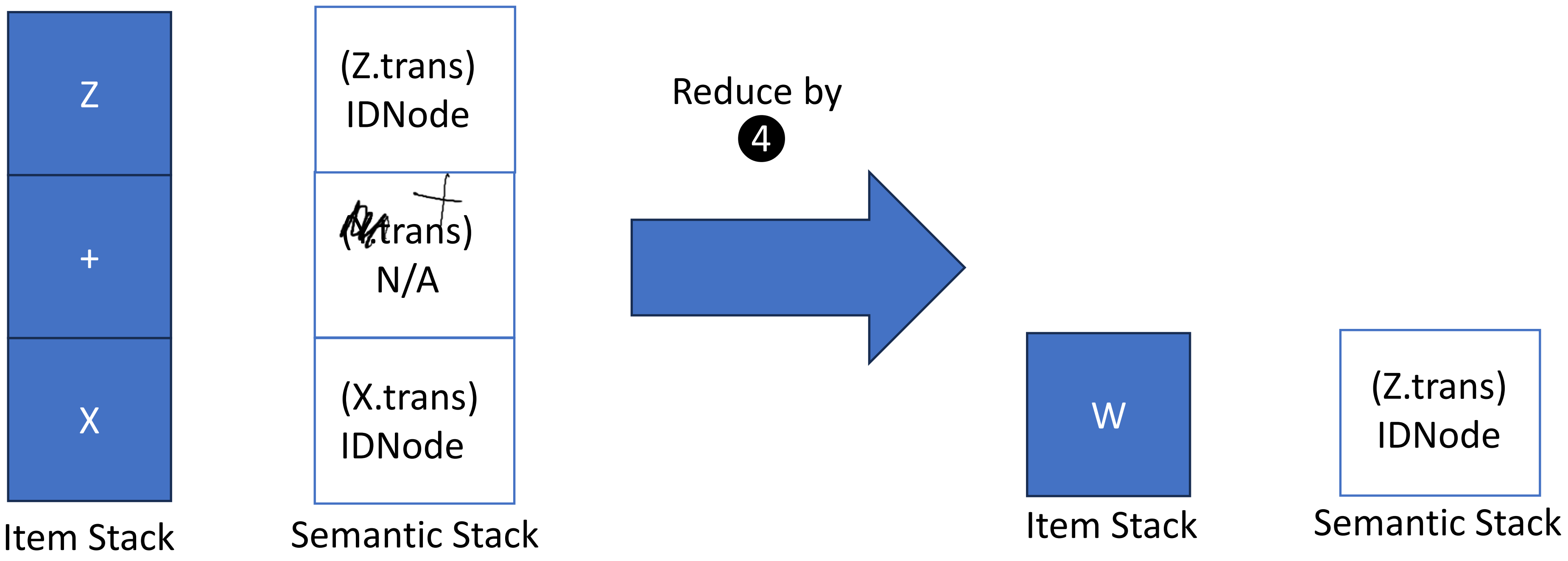
Nonterminal translations

- Read translations of popped RHS symbols

Bottom-Up SDT

LL(1) and SLR Language Limits

❹ W ::= X + Z { $$ = AddNode($1 + $3); }

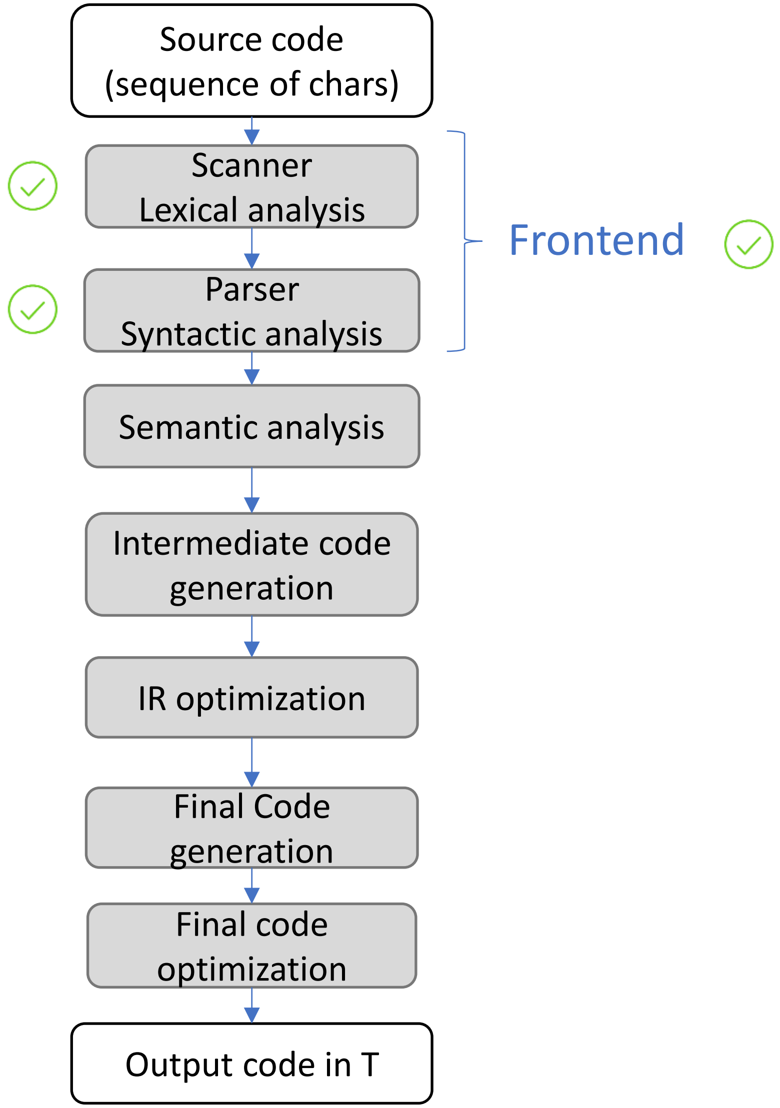


That's all for parsers!

Frontend Finished

ABET Course Outcomes

1. Understanding the role and structure of compilers, and its various phases
2. Constructing an unambiguous grammar for a programming language
3. Generating a lexer and parser using automatic tools
4. Constructing machines to recognize regular expressions (NFA, DFA) and grammars (LL and LR parsers)
5. Generating intermediate form from source code
6. Type checking and static analysis
7. Assembly/binary code generation



COMPILER
LAND
Code Generation
Execution
Runtime Environment
Intermediate Representation
Optimization
SDD
Parsing
Semantics
Lexical Analysis
Syntactic Definiton

Outline

Today's Lecture - Scope

Finish up Parsers

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Semantics

- Program meaning

Scope

- Name analysis

Parsing

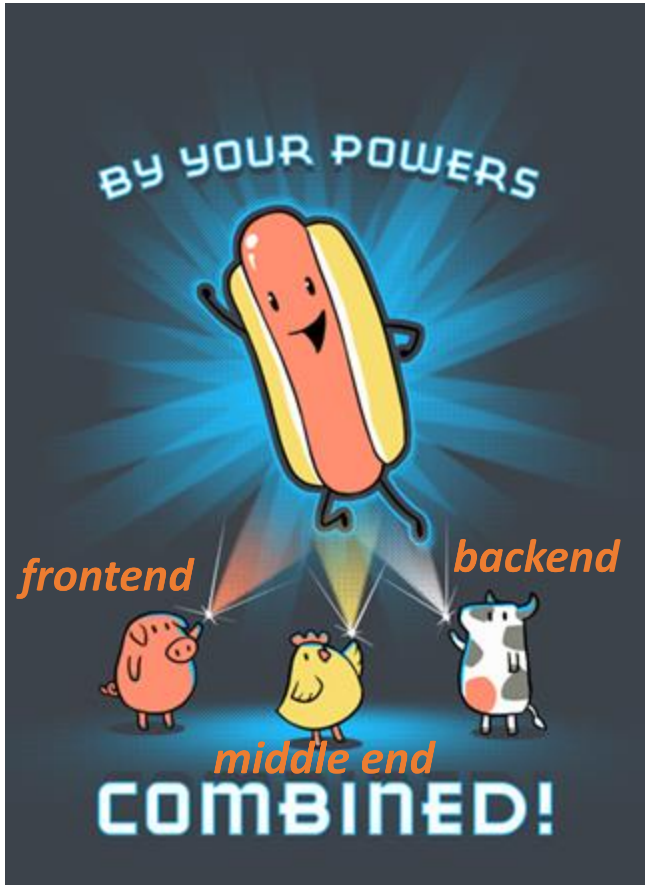
Semantics

Compilers: A Delicious Medley of CS

Today's Lecture - Scope

Learning compilers is kinda like a tasting menu of other CS domains

- Front end – Automata theory / discrete structures
- Middle end – Software Engineering / PL
- Back end – Architecture / Assembly code

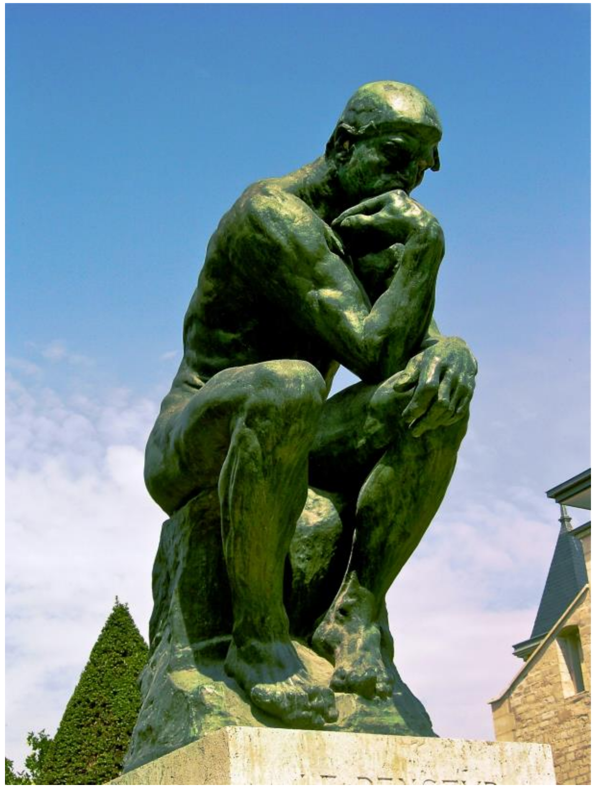


Language Design

Today's Lecture - Scope

Things are about to get a lot more code-y

- Maybe also a bit more cerebral
- Making a compiler empowers you to make a language!
  - How *should* a language be built?



Syntax vs Semantics

Semantic Analysis

Program Syntax

- Does the program have a valid *structure*?

Program Semantics

- Does the program have a valid *meaning*?

Goals

Semantic Analysis

Error Checking

- Is the program's meaning sensible?

Program "Understanding"

- To what does an identifier refer?
- To what operator does a program refer?

Example Program Snippet

```
a + b
```

Is this addition?
String concatenation?
User-defined operation?

Respecting Program Semantics

Compiler must facilitate language semantics

- Prerequisite: Infer the intended program behavior w.r.t. semantics
- Approach: Take multiple passes over the completed AST

One example: scope

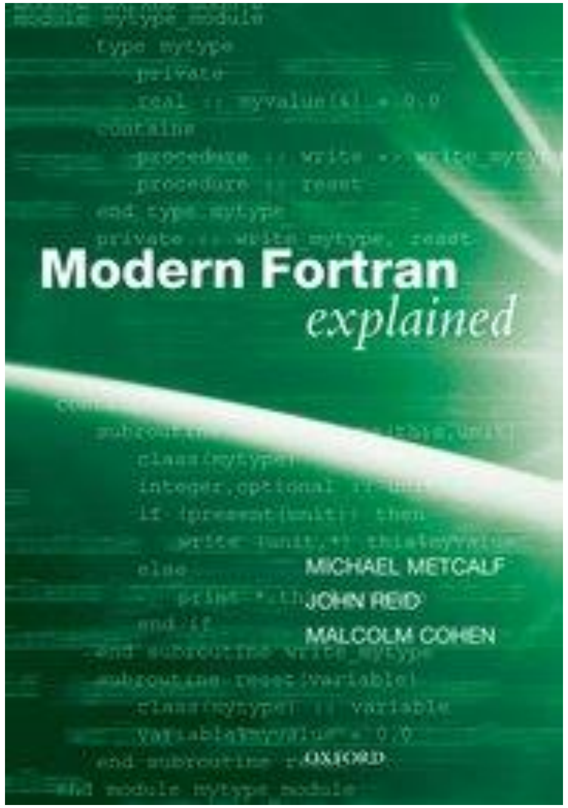
Scope
Semantic Analysis

- A central issue in name analysis is to determine the **lifetime** of a variable, function, *etc.*
- Scope definition: the block of code in which a name is visible/valid

Scope: A Language Feature
Semantic Analysis

- Some languages have NO notion of scope
  - Assembly / FORTRAN
- Most familiar: static / most deeply nested
  - C / C++ / Java

There are several decisions to make, we'll overview a couple of them



Scope Style

Scope Decisions

Based on nesting

- Static Scope
  - Check **syntactic blocks** *(bind at compile time)*

- Dynamic Scope
  - Check **calling context** *(bind at runtime)*

Based on execution stack

Scope Style

Scope Decisions

Based on nesting

- Static Scope
  - Check **syntactic blocks** *(bind at compile time)*

Based on execution stack

- Dynamic Scope
  - Check **calling context** *(bind at runtime)*


```
int street (){
      int a = 1;
      return a + b;
}
int main(){
    int b = 2;
    if (b){
        int c = 3;
      return hip();
    }
}
```

Other Scope-Related Choices

Scope Decisions

Many other decisions beyond scope type

We'll go through some of these together

Variable Shadowing

Scope Decisions

Do we allow names to be re-used?

```
void func(){
 int a;
 int a;
}
```

Allowed in Rust!

Disallowed in C

```
void funk(){
 int a;
 if (a){
   int a;
   if (a){
     int a;
   }
 }
}
```

Allowed in C

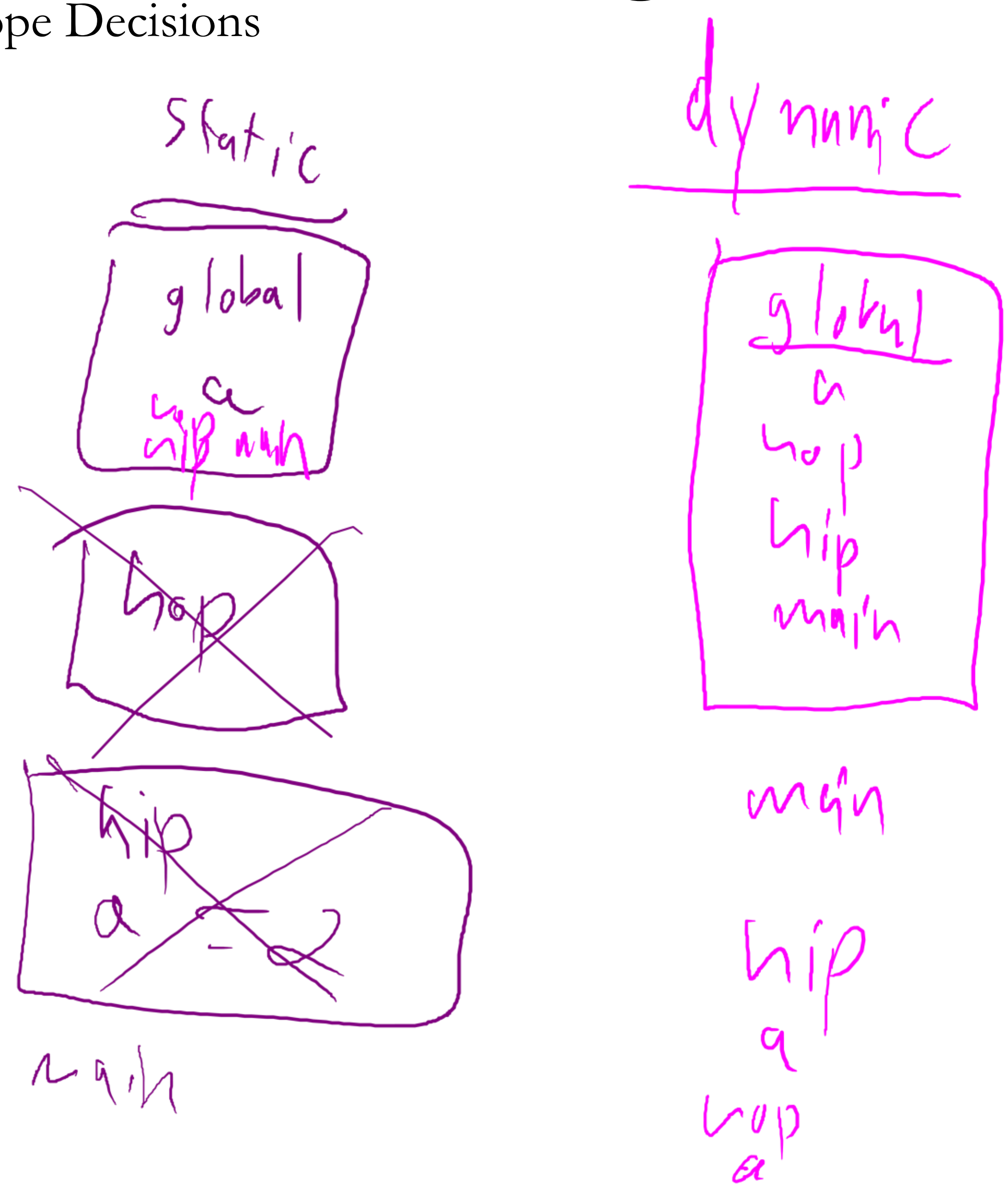
int smoothJazz;

```
void smoothJazz (int a){
 int smoothJazz;
}
```

Scope Kind & Shadowing

Scope Decisions

```
int a = 1;
int hop(){
      return a;
}
int hip(){
      int a = 2;
      return hop();
}
int main(){
      return hip();
}
```



Forward Reference

Scope Decisions

Do we allow use before name is (lexically) defined?

void western();

```
void country() {
    western();
}
void western() {
    country();
}
```

- If not, compiler may require 2 passes over the program
  - 1 to fill symbol table
  - 1 pass to use symbols

Overloading
Scope Decisions

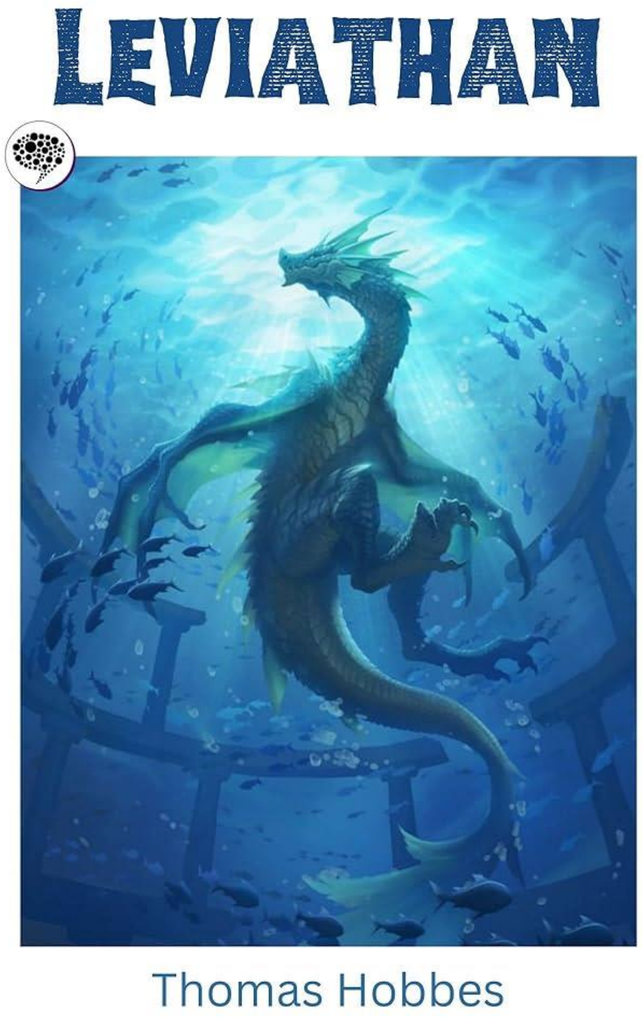
- Do we allow same names, same scope, different types?

```
int techno(int a){ … }
bool techno(int a){ … }
bool techno(bool a){ … }
bool techno(bool a, bool b){ }
```

Our Scope Decisions

Scope Decisions

- What scoping rules will we employ?
- What info does the compiler need?



Our Language: Scope Scheme

Scope Decisions

Static scoping scheme

- Programs use their lexical nesting to determine their scope

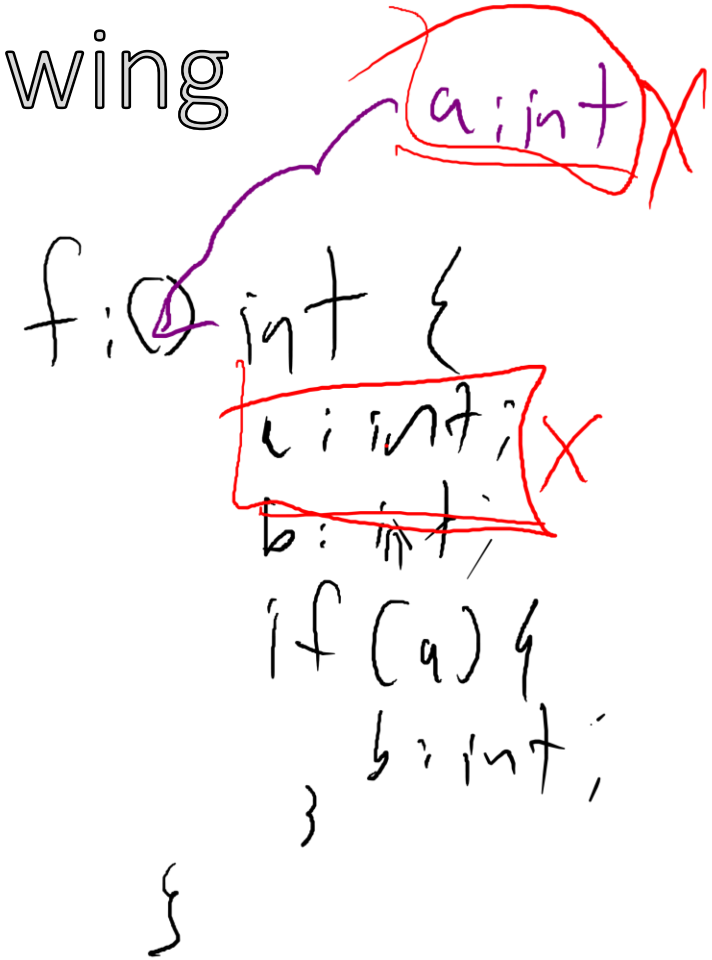
Our Language: Shadowing

Scope Decisions

Shadowing

C-like rules:

- Shadowing *between* scopes is allowed
- Shadowing *within* a scope is disallowed



The Sink statement

Scope Decisions

Remove a name from current and enclosed scopes

```
house : () void {
  a : int;
  a = 1;
  … a;
  a = 2;
}
```

```
industial : () void {
  a : int;
  a = 1;
  … a;
  a : int;
}
```

The Sink statement

Scope Decisions

Remove an in-scope name from current and enclosed scopes

```
house : () void {
  a : int;
  a = 1;
  … a;
  a = 2;
}
```

```
industial : () void {
  a : int;
  a = 1;
  … a;
  a : int;
}
```

```
edm : () void {
  a : int;
  a = 1;
  … a;
  if (true){
    a = 2;
  }
}
```

b : int

```
trap : () void {
  … b;
}
```

b = 0

```
blah : () void {
  b = 4
}
```

```
disco : () void {
  b : int;
  if (true) {
   … b;
  }
  b = 3;
}
```

Our Language: Others

Scope Decisions

Overloading

Nah

Forward Declaration

Nah